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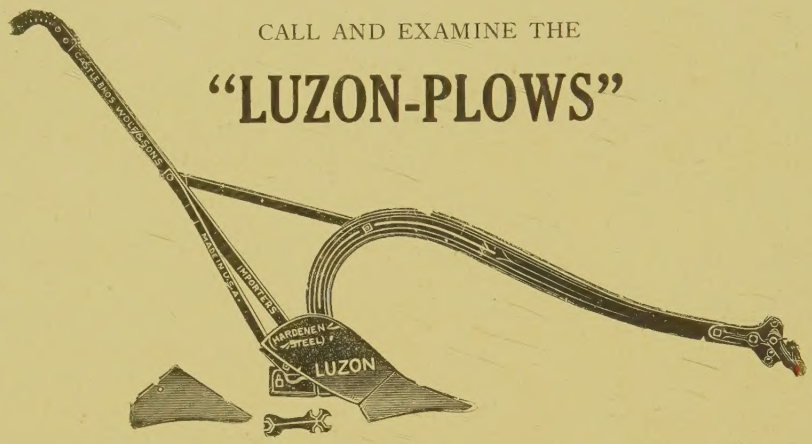

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Notes from the Chemistry Laboratory

1. Cassava

By Jose S. Camus

Samples of the three kinds of cassava now planted on the college farm have been analyzed by the writer (Table I). All the tubers were large ones from plants about one year old.

It is probable that 0.04 gram is about the minimum fatal dose of hydrocyanic acid. Even half as much might produce serious results. Therefore if an adult should eat as little as 140 grams of the red variety, containing 0.028 per cent. of hydrocyanic acid, fatal results might follow, were it not for the fact that the hydrocyanic acid is expelled in cooking. The absence of all but a trace of sugar is a notable characteristic of mature cassava tubers.

At the College of Agriculture, cassava has been planted since 1910. In 1913 the yield per hektare was as follows:

White petioled	11,000 per Ha.
Intermediate	7,000 " "
Red petioled	9,000 " "

TABLE I.

ANALYSES OF LOCAL CASSAVA

	White Petioled variety	*Red Petioled variety*	*Intermediate variety*
Moisture	67.84	67.11	69.39
Ash	4.15	3.81	3.15
Starch (Dextrose × .90)	24.88	25.79	23.82
Sugar	Traces	Traces	Traces
Dextrin	Traces	Traces	Traces
Crude fibre	1.795	1.816	2.27
Protein (Nitrogen × 6.25)	1.13	1.312	1.13
Hydrocyanic acid (Bark)	.043	.046	.048
Hydrocyanic acid (edible portion)	.023	.028	.023
Undetermined	0.19	0.13	0.22

2. Some Chemical and Bacteriological Effects of Clearing Grass Land By Burning

(*Summary of the work of* FRANCISCO QUISUMBING and GERARDO OCFEMIA.)

The grass lands of the Philippines, covered principally by cogon (*Imperata cylindrica: I. exaltata*) and talahib (*Saccharum spontaneum*), are commonly cleared by burning. By this custom a great deal of damage is done to the forests of the archipelago, since fires thus started commonly eat their way into the borders of timbered land and destroy young trees that if allowed to remain would eventually displace the grass.

But in addition to this objection to the practice of clearing grass lands by burning, it is conceivable that the soil itself may be injured. In the Philippine Islands the soils thus far analyzed are notably deficient in humus, and the practice of burning over cogon land may result in a considerable loss of this valuable soil constituent.

Experiments have been performed at this College that indicate a loss of about one third of the nitrogen and humus in the surface soil to a depth of ten centimeters; but, since the destruction that actually occurs is probably limited to about a third of that depth, such a result would necessitate a total destruction of the humus at the surface. This conclusion seems so improbable that these experiments are not given in detail.

According to one authority the burning of soils not only decreases the amount of humus and nitrogen that they contain, but limits nitrification, due to a destruction of the carbohydrates of the soil that serve as a food-supply for the nitrifying bacteria. Nothing is known of the rate of nitrification in our local soils.

In addition to the nitrifying organisms many other useful bacteria are present in the soil, for example those that decompose plant residues with the formation of humus, those that break down proteids with the liberation of nitrogen in a more available form, and those that fix and hold in combination the nitrogen of the air. The total number of bacteria present in a soil may be estimated in various ways. The method most commonly used consists in shaking a small sample of soil with a sterile saline solution, which is properly diluted and then used to inoculate a culture medium. Each of the individual organisms is supposed to develop into a colony, and after incubation for a few days the number of colonies may be counted with the naked eye.

Objections to this method are that a single culture medium is not adapted to the growth of every kind of organism apt to be present in the soil. The anaerobic bacteria in particular are not likely to flourish in the shallow dishes commonly employed in this work. The nitrogen-fixing bacteria refuse to grow in media rich in carbohydrates, and certain spores often fail to germinate. Again, organisms sometimes tend to adhere together, so that a group instead of a single organism may give rise to a single colony. All of these facts tend to make the method give low results, nevertheless it seems that data of sufficient comparative value may be obtained to make such experiments worth while.

Two surface soils that carried a heavy growth of cogon-grass were selected for a bacterial count by the method just described. Neither plot had been under cultivation for at least six years. Suspensions of the soils

in sterile saline solution, were diluted in three different ratios, and ten-cubic-centimeter portions taken for inoculation of a nutrient solution previously sterilized in an autoclave at 115° C. The nutrient solution was prepared by the following formula:

Water	100.0 c. c.
Mannite	10.0 gm.
$K_2H\ PO_4$	0.5 gm.
KNO_3	0.5 gm.
Agar-Agar	15.0-20.g

After five days incubation at 30° C. the colonies on each plate were counted, and the number of bacteria calculated per gram of moist soil. The grass on the plots was then burned and after a week new samples of soil were collected and the bacteria plated and counted as before. Rain fell during the week that intervened between the two counts, but the moisture content of the soil was found to be closely the same in both cases.

Bacteria count. (Millions per gram of moist soil.)

Plot Number.	*Before Burning*			*After Burning.*		
	I	II	III	I	II	III
1	437	355	590	114	80	150
2	36	26	49	27	19	59

Not only is the total number of organisms in the soil greatly diminished but even a superficial examination will reveal the fact that the colonies are entirely different from those obtained before. Those developed before burning were for the most part white colonies with sharply defined borders, while those obtained afterwards tended to be yellowish or greenish, with indefinite outlines. We may accordingly conclude that burning over cogon soil enormously reduces the number of organisms in it and profoundly modifies their character; but whether the change has been one of disadvantage to the farmer remains for future work to determine.

Having now considered the objections to the practice of clearing grass lands by burning, we may note its several possible advantages. The mineral matter which the grass has withdrawn from the soil is returned to the latter when the plant is burned. Our own analyses of the ash of the cogon plant gave 1.92 per cent phosphoric acid (P_2O_5) and 3.36 per cent. potash (K_2O). It would be an easy matter for one to estimate the manurial value of the ash produced on a hectare of land, if only that found on a measured tract were collected and weighed.

Results obtained by Russel and Hutchinson indicate that partial sterilization of soils may lead to an increase of the amount of ammonia that they contain, a result which may in turn increase the soil's productiveness. This effect is supposed to be due to the more ready decomposition of the proteid matter of the soils through the agency of the soil bacteria; but in soils so low in nitrogen as most Philippine soils it is useless to expect a benefit of this sort.

Certain soils have been improved by partial sterilization with carbon disulphide or chloroform. One of the theories that seek to account for the observed results states that soil protozoa at times live at the expense of the useful bacteria of the soil and prevent their proper multiplication. If this is the correct interpretation of the partial sterilization of soils through the use of antiseptics it may be that partial sterilization by burning will at times be of benefit. Russell and others found that long continued fire increased the productiveness of certain soils.

Practical gardeners and others have often observed that the number of cutworms and insects that attack cultivated plants may be decidedly reduced by burning litter upon the land before plowing. Weeds and their seeds of course tend to be destroyed in the process.

In India a method of cultivation known as the "rab" system has been long in use. Brushwood, straw, and manure are scattered over the soil and fires started that may burn for many days. It has been suggested that the beneficial effect derived from heating the land in this way may be due to a destruction of poisonous compounds contained in the soil; but since there is no evidence as to the nature of the toxic substances destroyed in this way it must rather be supposed that the benefit is due to the addition of mineral plant-food to the soil or to an alteration of the character of its bacterial activities. Recent experiments have indicated that there is possibly also an unlocking of the minerals of the soil by virtue of which potash and phosphoric acid become more available.

By way of summary it may be said that objections to the common practice of clearing grass-lands by burning are destruction of humus and consequent decrease in arability; the loss of nitrogen, which in our local soils is already too deficient; the repression of nitrification; and the destruction of useful bacteria in general. Benefits that accrue may be the destruction of the protozoal enemies of the soil bacteria, destruction of insect pests, and eradication of weeds. Mineral plant-food is added to the soil, and the heat if long continued may render the minerals of the soil more immediately available.

Whether the net result is a benefit or the reverse must depend on the soil type, the climate, and on the character of the crop to be grown. Only individual experimentation will determine the method of clearing that gives best results; and only further study will determine the relative weight of each of the foregoing considerations.

In practice, lands are often cleared at least expense by means of fire, but the agriculturist should bear in mind the losses that its use entails. At this College the crops that have the greatest value as exterminators of cogon are ipil-ipil (*Leucaena glauca*), caguios (*Cajanus cajan*), seguidillas (*Psophocarpus tetragonolobus*), and cowpeas (*Vigna unguiculata*). The two last mentioned can be cut up with a disc cultivator and plowed under. Other legumes suitable for use in a rotation are Ami's beans (*Soja hispida*) and centrosema (*Centrosema Plumieri*).

Work previously performed in this laboratory has resulted in the isolation of several of the organic constituents of cogon soils, pentose sugars and pentosans being of universal occurrence; but little evidence has been obtained of the presence of plant-poisons. It seems that the common infertility of cogon lands is due rather to poor aeration and drainage than to the presence of toxic soil constituents. Deep plowing should be practiced, especially since a hard, impervious layer (adobe rock) lies just beneath the surface in many local soils. By deep plowing and by the growth of leguminous crops upon land recently cleared by fire the intelligent farmer may improve aeration and drainage, may bring about nitrogen-fixation and nitrification, and may replenish the soil's depleted store of nitrogen and humus.

3. The Chemical Composition of Philippine Sweet Potatoes

By Segundo D. Labayen

Tubers taken for analysis were immediately washed and scraped free from skin. A representative subsample was then taken, weighed, sliced thinly and dried at a temperature of about 55° C. After drying the chips until they became quite brittle, the temperature was raised to 90° C. They were then taken out of the oven, cooled and weighed. The samples were then ground and placed immediately in glass-stoppered bottles. Moisture was determined by heating 5 gr. of the partially dried sample at 100° C. to a constant weight. The starch was determined by the acid hydrolysis method. Ash was determined in the five gram sample used for the determination of moisture. Each analysis was carried on in duplicate. Crude fibre was determined by the modified Sweeny method.

The plants from which the first twenty samples were taken were almost five months old. Sample twenty-one was from a crop 8-½ months old, and the remainder from crops 5 to 5½ months old.

TABLE 1. ANALYSES OF SWEET POTATOES GROWN ON COLLEGE FARM

Varieties.	*Specific Gravity.*	*Moisture*	*Ash.*	*Starch.*	*Dextrin.*	*Sucrose.*	*Glucose.*	*Protein.*	*Crude Fibre.*	*Yield K. tubers per Ha.*
		%	%	%	%	%	%	%	%	
Cahodo 1073*.....	1.12	67.10	0.77	21.28	....	....	....	0.69	....	....
Beattie 1627.....	1.04	76.12	0.72	15.44	....	....	....	0.50	....	6,300
Red Samar 334.....	1.10	77.99	0.91	10.11	....	....	....	0.50	....	....
Unknown Leyte 1081.....	1.09	72.10	0.81	14.33	....	....	....	0.31	....	....
Quenodiapa 342.....	1.11	73.83	0.92	14.58	....	....	....	0.25	....	....
Amorosa 336.....	1.06	69.63	0.97	19.87	....	....	....	0.88	....	10,400
Samar Big Yellow 333....	1.06	69.06	0.92	19.62	....	....	....	....	....	24,160
Manila Pula 349.....	1.05	71.38	0.79	18.60	....	....	....	....	....	10,300
Big Stem Jersey 1454.....	1.02	74.67	0.90	15.79	....	....	....	....	....	....
Montivedeo 115.....	1.09	72.79	1.01	15.57	....	....	....	....	....	....
Guinarosa 1070.....	1.09	65.57	1.34	24.68	....	....	....	....	....	....
Bumatus 1077.....	1.08	72.46	1.00	19.99	....	....	....	....	....	....
Kinawayan 1076.....	1.10	70.04	0.89	20.37	3.18	1.59	0.81	0.94	0.84	11,000
Caagarao 1066.....	1.09	66.74	0.97	24.67	3.28	1.70	0.26	0.63	1.02	11,200
Guinarosa 1070.....	1.06	63.08	0.90	26.30	4.77	2.03	0.55	0.81	1.17	5,500
Canegro 1074.....	1.11	66.98	0.87	22.90	4.78	0.59	0.32	0.50	0.97	9,600
Cabulan 1065.....	1.10	66.15	1.00	24.02	4.34	1.35	0.56	0.69	0.88	4,200
Tinogabang 1078.....	1.16	65.63	0.74	25.91	3.58	1.22	0.42	0.56	0.94	12,600
Tinampay 1075.....	1.07	68.63	2.04	20.77	4.02	1.51	0.86	0.44	1.03	8,500
Sinamporado 1071.....	1.11	65.08	0.96	25.65	4.18	1.38	0.21	0.88	0.82	9,600
Maragandang 350.....	1.06	65.98	0.99	21.87	5.56	1.06	0.52	0.56	0.46	11,000
Unknown Leyte 1080.....	1.10	69.92	1.02	21.30	3.01	2.42	0.46	0.81	0.68	14,200
Unknown Leyte 1081.....	1.12	64.44	0.84	25.30	3.75	1.08	0.98	0.56	1.18	9,500
Melakeña 1072.....	1.10	70.26	1.81	20.27	4.32	1.07	0.67	0.88	0.70	12,500
Caigbao 1068.....	1.16	65.69	0.99	25.45	4.35	0.77	0.40	1.06	0.70	6,000
Camiang 341.....	1.08	71.99	0.93	18.86	3.45	0.57	0.39	1.56	0.97	11,000
Inigcanto 337.....	1.10	75.75	0.81	15.64	2.21	0.65	0.33	2.44	0.87	17,000
Beriberi 346.....	0.99	75.28	0.88	16.39	3.56	0.53	0.28	0.69	0.68	11,050

* The figure after each variety is the record number of the Department of Agronomy.

Summary

The preceding table indicates that the specific gravity of sweet potatoes bears little relation to their content of starch or moisture. Specific gravity therefore cannot be used as an index

of the commercial value of the sweet potato in the same way as it is used in the case of the potato.

The percentage of moisture was found to vary between 66.08 per cent. and 77.09 per cent., *Guinarosa* 1070 being found to contain the least moisture, and *Red Samar 334* the most.

The varieties having the highest percentage of starch were found to be *Tinogabang 1078, Sinamporado 1071.* Unknown Leyte *1081, and Caigbao 1068, Guinarosa 1070 and* Unknown Leyte *1080* contained more sucrose than any of the other varieties analyzed for this constituent.

The writer wishes to express his obligations to Mr. Gonzalo Merino for a description of varieties and a statement of yields.

4. Composition and Uses of Banana Stems and Leaves

By Nemesio B. Mendiola, B.S.

The writer has analyzed a composite sample containing a mixture of leaves and stems of the local Saba banana in the same proportion by weight as they exist in the plant. The result of the analysis appears as follows; it is worthy of note that over ninety per cent of the plant consists of water, and that ash and crude fibre each make up about one fourth of the remainder.

	Maisture Basis.	*Moisture Free Basis.*
Moisture	93.10%	0.00%
Protein	00.62%	8.99%
Invert Sugar	0.43%	6.20%
Ash	1.69%	24.40%
Crude Fiber	1.74%	25.20%
Nitrogen Free Extract	2.42%	35.21%
Total	100.00%	100.00%

It is evident that the dry matter of banana stems is approximately half crude fibre and ash. Assuming that half of the nitrogen-free extract and protein is digestible we have approximately only one and one-half per cent. digestible material in the green fodder, an amount that would seem to make it useless for feeding purposes.

Work-cattle (vacas) fail to show any inclination to eat the material whether alone or combined, even if they are starved to a reasonable extent. Carabaos coming from hard work show an appetite for the green leaves, but not for the stem.

From an agronomical point of view, perhaps the most important use of the stems and leaves is as a compost. Professor Charles F. Baker states that in Cuba some work was done on composting banana stalks. In one case banana trunks were interlayered with dirt in a space of about 8×10 meters. In no case did they slice or cut the trunks into pieces. This was a little before the beginning of the rainy season there, and at the end of that season they found that the first pile was already so well rotted that the compost might be used for seed beds.

Analysis of the ash of the stem by the writer gave:

K_2O	36.67%
P_2O_5	4.28%
MnO	0.15%
CaO	9.59%
MgO	1.59%

It appears that the most important constituent of the ash is potassium oxide, which constitutes over one third of the whole. The banana stem which furnished the ash analyzed above, contained 1.34 per cent ash and .03 per cent nitrogen. According to the preceding analysis a ton of the green stem should therefore contain:

0.3 Kg.	N.
4.9 Kg.	K_2O.
0.5 Kg.	P_2O_5
1.2 Kg.	CaO.
0.2 Kg.	MgO.

5. The Banana Fruit

By Jose Dacanay, B. A.

The banana is one of the most important economic plants of tropical and sub-tropical regions. Its exact origin is not yet definitely settled, but we can at least say with certainty that its original home was somewhere in the south-eastern part of Asia, most probably in the Malay Peninsula, or in the Malay Archipelago.

In spite of its ancient culture and wide distribution, the banana did not receive the attention of scientists until about a generation ago. Up to that time, works on the banana were comparatively scarce, and it still offers a wide field for scientific research.

It was not until the beginning of the 19th century that the banana became a product of commercial importance, when it was imported into northern markets in the United States and Great Britain. From that time the commerce grew wonderfully, and the industry in North Central America, the Canary Islands and the West Indies kept pace with it.

At present the banana is only used in temperate countries as an article of dessert. The following figures show the rapid development of the banana trade in the United States and the enormous quantities imported from the West Indies and Central America.

Year.	*Value.*	
1878	₱ 539,535	(1)
1880	682,755	
1885	2,095,225	
1895	4,674,861	
1900	5,877,835	
1902	7,307,437	
1912	14,638,330	(2)

The fruit is a staple food in the tropics. Its use has spread gradually to the northern temperate countries especially to the United States and Great Britain.

TABLE I.

Analyses of Unripe Bananas. (3)

Substances.	*Dried.*	*Fresh.*
Water	5.75%	75.11%
Oil or fat	0.69%	0.18
Sucrose	....	....
Glucose	1.75	0.29
Starch	42.11	11.11
Albuminoids *	5.13	1.35
Gums, etc.	1.88	0.36
Digestible fiber	36.87	10.07
Woody fiber	2.52	0.66
Ash (mineral matter)	3.30	0.87
	100%	100%

* Containing nitrogen: dried, 0.84; fresh, 0.22.

The varieties of bananas that require cooking are commonly known as plantains. The plantain has the greater food value.

TABLE II.

Composition of Plantains. (3)

Fleshy matter of pulp. 64.5%; skin, 35.5%.

	Fresh. pulp.	*Flour from dried pulp.*
Water	62.86	11.80
Fats	.44	1.05
Albuminoids *	1.58	3.75
Glucose	2.25	5.34
Starch	22.16	52.64
Tannin, gums, etc.	.50	1.20
Digestible fibre	9.01	21.37
Indigestible fibre	.40	.95
Ash (mineral matters)	.80	1.90
	100.00	100.00

* Containing nitrogen, fresh pulp, 0.25; flour from dried pulp, 0.60.

TABLE III.

Composition of Banana Meal. (4)

	Jamaica.	*Surinam.*	*Surinam.*
Water	15.5	14.3	13.1
Albuminoid true	2.5	2.3	2.3
Starch, sugar, gum, etc.	77.7	79.5	58.7
Oil	1.0	0.7	5.5
Fibre	0.7	0.9	8.7
Ash	2.6	2.3	10.7
Nutrient Ratio	1.32	1.35	1.22
Nutrient Value	.82	.83	.74

The preceding tables indicate that unripe bananas contain starch as their chief carbohydrate, which is converted into sucrose (cane sugar) as the banana ripens. With bananas that are overripe, and with some varieties from the beginning, the chief carbohydrate is invert sugar.

Most varieties of bananas contain an amount of dry-matter that hardly exceeds one-fourth the total weight of the edible portion. For convenience in consumption, and for more certain preservation, unripe bananas are often dried in the sun or in a rotary drier with a current of warm air. The product is afterward ground and sold under the name of banana-meal or banana-flour.

The analyses cited above indicate that banana-flour has a considerable food value. Nevertheless, its content of protein is so low that it could not serve as the basis of a regular diet unless used in connection with meat, legumes, or other foods rich in nitrogen. If we assume that an adult requires a gram of proteid daily for each kilogram of body weight, and that he needs to derive fifty calories of heat from the digestion of his food for each kilogram of body-weight, any one of the following combinations would be a proper daily ration for a man of 70 kilos (154 pounds):

1. 500 grams banana flour (10% water).
   400 grams rice (12.5% water).
   100 grams dried fish (22.% protein).

2. 500 grams banana flour (10% water).
   300 grams rice (12.5% water).
   200 grams dried beans (20% protein).

3. 500 grams ripe bananas (75% water).
   250 grams corn meal (8% protein).
   500 grams wheat bread (9% protein).
   70 grams butter.

4. 500 grams banana flour (10% water).
   500 grams canned baked beans.
   250 grams canned salmon (20% protein).
   100 grams walnuts or Brazil nuts.

The above rations are calculated on the basis of the assumption that the banana flour contains 4.7% digestible protein, and some allowance has been made for the supposed inferior digestibility of the proteins of banana flour as compared with those of wheat flour (5, 6). They are intended to suggest in about what proportions preparations made from banana flour should be combined with more nitrogenous foods in order to furnish a satisfactory diet. Of course no one of the suggested combinations would long prove palatable unless modified by introducing salads, fruits, green vegetables, and condiments, articles whose actual food value may be neglected in the amounts in which they are usually consumed. The cook will also need to use all his ingenuity in reproducing with banana flour the various kinds of pastry commonly prepared from wheat flour. He will probably discover that certain dishes cannot be prepared from banana flour alone, but that wheat flour needs to be added in order to make a dough of proper consistency

The analyses and rations just presented will suggest that we have in the banana a fruit that may be used to modify in a desirable way the rice diet so common in the tropics, and it is very possible that such a modified diet may serve to ward off beri-beri. Banana flour will at any rate afford a welcome relief from the fare of rice, fish, and canned goods which European settlers in the tropics find so monotonous. It has also been claimed that gruel made from banana flour is an excellent food for infants.

In the preparation of banana flour a starchy variety should be selected. (The Saba is the best local variety.) The bunch of fruit is harvested when one or two of the bananas have turned yellow, the fruit is peeled, sliced thin,

and dried in the sun until dry enough to grind. It may afterward be dried in an oven if it is to be kept a long time. If the moisture content is reduced to ten per cent. the preparation will keep indefinitely. In a process recently patented the peeled green bananas are washed with brine, then with water, to remove the compound that would otherwise stain them brown, and are afterward dried in the usual way (7).

Bananas are sometimes sliced and dried in the sun, then packed in boxes after the manner of figs. Students of one of the Agronomy classes at this College have tested the different local varieties and find that the Morado, Latundan, and Lakatan give the sweetest and best flavored product. The superiority of these varieties is evidently due to their high content of cane-sugar as shown by analyses carried out by the writer in coöperation with other members (a) of the class in Chemistry.

(a) A. Constantino, Luistro, San Miguel, Montellano.

TABLE IV.

Analyses of Local Varieties of Bananas.

Variety.	*Edible Matter.*	*Moisture.*	*Crude Fiber.*	*Nitrogen.*	*Protein (N ×6.25)*	*Sucrose.*	*Invert Suagr.*
Bungulan	73.87	70.00	1.58	0.11	0.69	9.19	5.88
Lakatan	65.49	70.52	0.90	0.19	1.21	13.19	2.90
Latundan	78.87	68.12	0.84	0.20	1.27	15.90	3.60
Morado	66.67	71.77	2.12	0.15	0.97	14.66	2.24
Saba	64.65	75.64	0.73	0.29	1.84	4.47	3.25
Ternate	63.46	65.29	0.78	0.14	0.90	5.43	5.98

In Central America and Venezuela there are always large quantities of bananas that are unsuited for shipment and which consequently have been wasted. Tests have recently been made that show that this material can be fermented economically and converted into alcohol. In another instance banana flour was used for the production of alcohol, one hundred kilos at a cost of about ₱1.40 for the raw material (8).

Our knowledge of the chemical composition of the banana has been considerably increased in recent years. We know that the odor of the banana fruit is due to amyl acetate. The transformation of starch into sugar in the final stage of ripening is accompanied by a decrease of total carbohydrates due to respiration. The most prominent enzymes present in the banana are amylase, which converts starch into glucose; sucrase, which converts cane sugar into invert sugar; and enzymes that decompose fats and proteids (9).

The analyses presented here constitute the only work that has been done up to the present time on the chemical characterization of the local varieties of bananas.

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3. Kew Bulletin, No. 92, (1894) p. 308-310.
4. Exp. Sta. Record 507.
5. Z. Nahr. u. Genussm. *22*, 175.
6. Z. Nahr. u Genussm. *22*, 179.
7. U. S. Pat. 1,053,955.
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Current Literature

The West Indian Bulletin, Volume 13, No. 3, contains papers on rubber and miscellaneous subjects presented at the Agricultural Conference of 1912. Papers on rubber include reports of experiments in various parts of the West Indies and in British Guiana. The work includes many species, but especial attention has naturally been given to Hevea, Castilloa and Sapium species; Funtumia has also received attention with results of interest; the Manihot rubbers have not been found worth working with in the West Indies.

The general conclusion from all of the work is that Hevea is the only rubber of demonstrated agricultural value. Limited experiments indicate that it grows on land which is merely kept clear in Trinidad, at a rate comparable to what is expected with the clean cultivation customary in the Malay States. This evidence is not obtained on a large scale, and is altogether contrary to experience in the eastern tropics. It is recognized as impracticable to give clean cultivation to Hevea where labor costs West Indian prices. Without this expensive cultivation, the estimated cost of planting and harvesting given on page 263 shows that 5-8 of the total expense of handling a plantation goes into tapping of trees, and that with labor at West Indian prices, the cost of the rubber must be figured at one peso, Philippine currency. The price of labor already alluded to is that which obtains in those parts of the Philippines where labor is much in demand; it is 80 centavos Philippine currency

Experiments with Castilloa, even dealing with reasonably old trees offer no encouragement. Experiments in Dominica on fifty trees from twelve to twenty years old show an average yield per tree of the oldest trees of 1 lb. 1 oz. while the thirty-seven trees twelve or thirteen years old yielded only 2.2 oz. a year. The four oldest trees were of such a size that twenty-five would completely occupy an acre of land. If the yield be figured as 1.5 lbs., the best which has been observed, the yield per acre would be only 37.5 lbs., which is valued at three shillings a pound. "This comes to £6,—and this after twenty years of waiting and when the trees are at their best." It is objected to the Castilloa rubber that the trees bear late, that the rubber is of only fair value, and that, as the trees are tapped, there is no wound response, the yield from successive tappings, even far apart, being less and less, with the threat of finally ceasing altogether. Even the tapping is not so much cheaper as has been expected, experience in Dominica indicating that a number of Hevea trees can be tapped in the same time as one Castilloa.

It must be observed in reviewing these results that the limited experience up to date in the Philippines is altogether different. Hevea has been found here to endure fairly well competition with other small trees, but not to tolerate at all the presence of grass and weeds. Castilloa, on the other hand, has shown itself able to thrive on comparative neglect. Personal reports from one plantation where Hevea and Castilloa are both grown show the Castilloa to have been first to produce, cheapest to grow and to harvest, and to have paid all cost to date, while the Hevea was continuing to incur cost.

The Cultivated Root-Producing Aroids

Yautias, Gabis, Dasheens, Alocasias, and Cyrtospermums

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Thesis presented for graduation from the College of Agriculture No. 21

Introduction

The economic root-producing aroids, which are natives of the tropical countries, are receiving little attention except in two or three regions like Hawaii and the West Indies. In the Philippines, as in some other tropical countries, vast areas of swampy places where no other crops can be grown are found, and such lands are the ones best fitted for the growing of the cultivated aroids.

The increased demand throughout the world for starchy roots, for alcohol, and stock feeding, and other uses, is so great that extensive culture of these crops is likely at no distant date to be one of the important lines of agricultural endeavor in the Philippines.

The family *Araceae* as a whole is not important to Agriculture, but the large group of plants belonging to the *Colocasieae* is of great value because it contains about forty-five species of Colocasia of Polynesia and Malaya, four economic species and more than thirty varieties of Xanthosoma of the West Indies and Tropical America, and the Alocasias of the Orient.

The different genera are usually distinguished by the character of the leaves. Cultivated aroids having leaves with a closed sinus are recognized as Colocasia; those with a completely open sinus as Alocasia; those with a margin interrupted in the sinus as Xanthosoma. In many cases, leaves of Alocasia will show characters so similar to those of Xanthosoma that they can not be distinguished. In this case, we use the characters of the tubers and the inflorescence.

The cultivation of the gabi (*Colocasia antiquorum*) extends from the Pacific Islands, Malay Archipelago, China, Hindustan, Madagascar, and the whole region of Tropical Africa, across the West Indies. In the eastern part of Africa, it is found cultivated very extensively and with various local names. It has been reported that gabi is growing in Angola, and in the interior part of Liberia. European botanists saw it in Egypt hundreds of years ago, but designs on the monuments and pyramids of the ancient Egyptians do not give any indication of its existence during the greater Egyptian periods of antiquity, Pliny speaks of it as Arum Aegyptium. Aaronsohn says that gabi is still found growing in Palestine, Syria, and Beirut, and even now the Arabs call the plant "colcas." The culture of gabi in those regions is supposed to be old.

Chinese literature does not give any evidence of its existence in China before 100 B. C. (1) The first European navigators saw the plant cultivated in Japan, New Zealand, and Fiji, in consequence perhaps of an early introduction, and without any representation of the wild type.

The scientific name of gabi, Colocasia, has a close resemblance to the word "colcas" or "culkas" which is an old Egyptian name. Delile writes "colcas" as "Kolkas" or "qolkas." The word "colcas" has a great similarity to the Sanskrit name "kuchoo" which seems to indicate that the plant came from India. De Candolle does not seem certain as to whether "colcas" corresponds to the name of the group of plants which now belongs to the genus Colocasia.

No records of the introduction of gabi into America by white men are available. Many botanists have reported that gabi was under cultivation in America centuries ago. Seeman says that Colocasia existed in Panama with the name "oto." Mr. Barrett thinks this plant a yautia and not a gabi. (2)

In the West Indies, especially in Porto Rico and Cuba, gabi has the name "malanga" which, however, is applied to other similar plants. It has been suggested that gabi came into America from Africa, because the importers of negro slaves found it of great advantage to supply the slaves with this food, so that during the introduction of slaves into America, the plant came with them. The word

(1) Origin of Cultivated Plants. De Candolle, pp. 73-75.

(2) The Yautias of Porto Rico, O. W. Barrett, P. R. E. S. of Agric. Bul. 6, p. 8, (1905).

"malanga" is similar to the African word "malombo" which supports the suspicion of its African origin.

Xanthosoma, as stated by Barrett. is no doubt native of tropical America, and Cook (1) believes Xanthosoma to be the oldest cultivated plant of the world. This proposition is strongly advanced by Cook in his theory that the cultivation of economic plants originated in the Caribbean region. But Colocasia may have originated in the Pacific Islands and Malay and Indian regions. As De Candolle states, it is cultivated in tropical America, but in far less number of varieties than in Asia or Africa. Gabi is wild in India, as Roxburgh and Wight state, likewise in Ceylon and Sumatra and the Islands of the Malay Archipelago.

In places where the plant grows wild, the common names are very ancient and different from each other. The Sanskrit name is "kuchoo."

In India it is styled "Kachu" (there are very many local names); in Ceylon, "gahla." Some of the Malay names are "keladi," "tallus," "tallas," "tales," and "taloes"; from which may come the well-known name of the Pacific Islanders, "taro" or "tallo." Other local names are "Dalo" in the Fiji Islands, "imo" in Japan, "nere" in Bengal, "kladdi" in Malacca, "mon" in Cochin-China, "madere" in the French Antilles, "quiquisque" in Guatemala, "soojo" or "songe" in Madagascar, and "gabi or "gabay" in the Philippines.

Alocasia, which was before called Colocasia (Schott), is widely different from Colocasia. The aborigines of Tahiti call it Ape, and of the Friendly Islands "kappé." In Ceylon it is called "habara," according to Thwaites; in the Philippines, "Badiang" (Visayan) or "Bigá" (Tagalog); in New Caledonia, "pera." The plant appears to be wild in Tahiti and the Pacific Islands, the Malay regions, Ceylon and India.

Yautia (Xanthosoma) according to Barrett, means "place of" (ya), the spiny rat, Capromys sp. (hutia), which is found in tropical America and feeds on the roots of the plant. The origin of "tannier" is not definitely known. The sound "r" is not pronounced in the West Indies, so that either "tannia" or "tania" is found in recent publications on the subject. "Eddo" is an African word for Colocasia, but it is frequently applied to "yautia." "Malanga" is the Arawak name for gabi and it is still used by the Cubans for any similar plant.

The American nativity of the true yautias is definitely indicated by the wild species of Xanthosoma. One of the species grows in the mountains of Guatemala, and is sometimes eaten by the natives when food is scarce. The cultivated varieties of yautia grown in that region are widely different from the wild ones. The wild varieties seem to be similar to the palma yautia of Porto Rico.

The existence of wild yautias in the most remote parts of Guatemala makes it easier to understand how, even as acrid as the plant is, it finally came into cultivation by men of the past.

There is the possibility that gabi like other plants such as bananas may have been brought to America from the Islands of the Pacific in prehistoric times. Methods of cultivating gabi in flooded lands or muddy soils are found everywhere in Polynesia, and it is supposed that such practices or methods have been adopted by the natives who have known the plant in its original habitat. The propagation and cultivation of the plant in the olden times was carried on along sides of streams in the forests, or along steep ravines and these places are to be found under cultivation with gabi even at present.

The prospective commercial importance of the cultivated root-producing aroids, and their profitable cultivation in the tropics demand their careful investigation. They are extensively used by millions of tropical people. The plants being indigenous to the tropics will thrive and produce abundantly under extreme tropical climatic conditions, where most temperate vegetables can not be grown. The acrid substance found in the leaves and petioles, and in some varieties in the tuber, make it immune to most diseases and animal pests. Its methods of multiplica-

(1) Promising root crops for the South. I. Yautias, taros, and dasheens, by O. W. Barrett. II. Agricultural History and Utility of the Cultivated Aroids, by O. F. Cook, U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin No. 164.

tion offer a great advantage under tropical climates, because they spare the great difficulties of germination, care of seedlings, and transplanting required by most tropical plants.

Both from a cultural and dietetic standpoint, the yautias, dasheens, and gabis hold third place among tropical root crops. They possess many points of superiority over either sweet potatoes or yams. Tubers of these plants already form a great part of the food of the laboring classes of the people of tropical America and the Islands of the Pacific.

The present interest in roots which may be used in the production of starch, flour, alcohol, and vinegar, as well as for stock feeding, will bring the plants to the highest level of importance as tropical vegetables. If an industry such as the manufacture of starch or flour from the best varieties of the cultivated aroids can be created in the tropics they will at once have a great agricultural value.

The yield of many of the varieties of yautias and dasheens may be stupendous as compared to that of sweet potatoes. As to the food value of these plants, analyses will show that the per cent of protein, carbohydrates, and fat is almost equal that of the Irish potato, sweet potato, cassava, and yam.

Uses of the Cultivated Aroids

As starch plants, the yautias, and perhaps some of the varieties of dasheens and gabi, will in a measure compete with cassava. Their yield per acre is much larger in some cases, being 10 tons from yautia, and 6 tons from cassava. Starch made from white varieties of yautia is as white and brilliant as cassava. Starch from even the colored varieties will bring a high price in the market. The per cent of starch in yautia is from 17 to 24.

Flour made from tubers of yautia and gabi is considered more nutritious and palatable than that from cassava. It contains no trace of hydrocyanic acid. Flour from gabi is easily digested by invalids and infants, and by persons of weak digestive apparatus. (1)

(1) Promising Root Crops for the South. U. S. D. A. Bul. 164, p. 15, (1910).

In many parts of the tropics the plants are used as shade plants for young spice, cacao, and coffee.

In lands where these plants are native, they are prepared for the table in a variety of ways. The young leaves of Colocasia are everywhere stewed for use as greens. The cultivated varieties, as a rule, contain far fewer raphides than the wild forms, and what they do contain are gotten rid of by cooking. If necessary, vinegar can be used to get rid of these disagreeable little needles. From the trunk of Colocasia, flour or starch may be prepared. The corms and offsets of Colocasia and Xanthosoma are prepared in the same variety of ways as the potato and sweet potato, that is, boiled, baked, roasted, or fried, sometimes whole, sometimes sliced, and by themselves or with the use of a variety of condiments. Either coconut meat or coconut milk is commonly used with them in the Philippines. The very young leaves make a good salad. A pickle is made from the main "root" in India.(1) In New Zealand the tubers are said to be pounded into a paste, from which biscuits are made. A curry is also made from the leaves in India.

In the United States, the office of plant Introduction has aroused a great interest in these plants during the last few years, and a "Dasheen Club" has been formed, which conducts a propaganda in the interest of their wider use. This club has prepared a booklet of receipts and has served banquets, at which the dasheen was a chief ingredient of all courses. As the dishes which have been developed in this work are unknown in the Philippines, the following recipes are copied from Circular 127, Bureau of Plant Industry, United States Department of Agriculture, and from typewritten papers sent directly by that department.

Baked Dasheens

Dasheens, large or small, may be baked like potatoes, in a moderately hot oven until soft. They should be first washed and scrubbed to remove fibrous part of the skin. The time required is just the same as for potatoes,

(1) Watt: Commercial Products of India, p. 399.

depending upon the size of the tuber. They should be served hot. Season with salt and plenty of water and pepper if desired. Gravy instead of butter may be used.

If desired, the rough skin may be scrapped off before baking and the dasheens eaten entire.

The dasheen when baked is mealy and the flavor is much like that of the white potato, but more or less suggestive of boiled chestnuts. Baking is one of the best ways of preparing this vegetable, specially if tubers are small.

Stuffed Dasheens

Scrub and bake medium and small dasheens; cut off one end, or divide and remove the contents; mash and beat up with cream (or milk) and butter, and season to taste; then fill the empty skins, spread over the filling some beaten eggs, sprinkle with breadcrumbs and brown in the oven.

Boiled Dasheens

Large dasheens are preferable for serving in this way. They may be boiled in the skin soft, then peeled and cut into pieces of suitable size and served without further preparation. Seasoning is to be added at the table, as in the case of baked dasheens. If small tubers are used, they may be served in the skin, but the appearance is not appetizing. The skin is removed more easily than that of the potato. The mucilaginous juice, which collects beneath the skin of the tubers when boiled, is more noticeable in the small ones, and they are therefore not so well adapted for boiling as for baking.

Scalloped Dasheens

Raw dasheens are sliced thin, put in layers in a well-buttered baking dish; season each layer with the salt and sprinkle each with flour. Nearly cover with rich milk and bake.

This method of serving the dasheen will be found particularly well adapted for banquets or formal dinners, but in such cases individual baking dishes or casseroles should be used.

The above recipe may be varied by using less butter and adding grated cheese. Pepper may also be used in seasoning if desired. Cold boiled, instead of raw, dasheens may be utilized in these recipes.

Fried Dasheens

Cut boiled dasheens either warm or cold, into rather thin slices, season with salt and fry quickly. If fried too long, the vegetable becomes too firm and dry. It is likewise important not to allow the dasheens to dry out before frying.

Boiled dasheens may also be mashed or put through a potato ricer, as described in the following recipe, and made into cakes or croquettes and fried. The croquettes may be dipped in egg and rolled in cracker crumbs before frying.

Mashed Dasheens

On account of the somewhat mucilaginous character of the dasheens, they are not recommended for mashing in the ordinary way. They do, however, make a most excellent dish when put through a potato ricer. For serving in this way the tubers may either be peeled, cut up and boiled in salted water, or boiled in the skin, peeled and then put through a potato ricer. In the latter case they may be seasoned either before hand and put through the ricer again, or at the table. It should be remembered that riced or mashed dasheens may be a little dark, especially when large tubers have been used.

Creamed Dasheens

Peel, cut into half inch cubes, put into salted boiling water and cook until soft; drain and pour over each quart one cup of white sauce made as follows:

1 cup milk.
1½ tablespoons flour.
1½ tablespoons butter.
1 teaspoon salt.
Pepper to taste.

Scald the milk; melt the butter in a sauce pan, stir in the flour a little at a time and cook until smooth; add the milk slowly, stirring constantly; add the salt and pepper and cook over boiling water until the mixture thickens.

Prepared in this way, dasheens resemble white potatoes, except that when large tubers are used they are slightly colored. The characteristic flavor of boiled chestnuts is retained.

Candied Dasheens

Peel raw or parboiled dasheens and cut into thick slices or strips; prepare

a syrup made in the following proportion:

1 cup sugar.
2 cups hot water.
2 to 3 tablespoons butter.
Salt if desired.

Either granulated or brown sugar may be used, the flavor of the dasheens being better retained with the former. Cinnamon may be added if desired. Boil in this syrup in a covered dish until soft, and brown in the oven.

Dasheen Pie

Any recipe for sweet potato pie will probably do, but the following is suggested as being economical and otherwise satisfactorily. The dasheens should be boiled and riced as usual.

(1) 1 pint dasheen (boiled or grated cold)
¼ cup butter
¾ cup white sugar
2 eggs (white and yolks beaten separately)
1 pint milk

(2) 1 pint dasheen (boiled or grated cold)
½ cup butter
¾ cup white sugar
1 teaspoonful cinnamon
½ teaspoonful nutmeg
4 eggs (white and yolks beaten separately)
1 cup milk
1 lemon juice and rind

(3) 2 cups of riced dasheen
¼ cup butter
¾ white sugar
½ teaspoonful of cinnamon

Bake in a deep pie tin. Serve warm or cold.

Dasheen Pudding

Same as either of the above recipes for pie. Bake without crust in a deep dish well buttered. Cool before serving.

Dasheens as Filling for Fowls and other Meats

2 parts dasheen
1 part bread
1 egg

Butter or suet according to quantity above. Season to taste with salt, pepper, sage, and onion.

The dasheens should be boiled and well mashed and put through a potato ricer while warm.

Dasheen Soup

3 cups of boiling water
3 cups of milk
3 cups riced dasheens
3 tablespoonfuls butter
Salt and celery salt to taste
Parsley or grated onion if desired

Boil and rice the dasheens as described. Into a double boiler, put the boiling water and add the milk and dasheen. Bring the mixture to boiling and cook for 5 to 10 minutes. Season and serve.

Dasheen Shoots

1. Cut the blanched shoots into 2 inch lengths, pour an abundance of boiling water, add salt, and boil for 12 minutes. Drain and pour on enough cold milk so that the shoots will be completely covered when it boils, season with salt, and boil for 5 minutes; drain, season with butter, and serve on toast or plain. Cream sauce may be used in serving, if desired.

2. Instead of boiling in milk after draining off the first water, add a little piece of bacon or other fat or meat and then cover the shoots with cold water, season with the salt and boil for 5 minutes. Drain and serve.

The purpose of cold milk or water, after the first boiling, is to prevent the shoots from becoming too soft. Fat of milk or meat seems to destroy the acridity.

Dasheen corms may also be forced with bottom heat in a green house and the blanched shoots, by special cooking to remove the acridity, may be used like asparagus. Shoots are very tender and have a delicate flavor, suggestive of mushrooms. There are, perhaps, few plants so well suited for forcing purposes as the dasheens.

Dasheen Greens

The young leaves of dasheens and other plants of this class are used for greens, like spinach in all countries where these crops are grown. The leaves are seemingly in more suitable conditions for greens in the first half of the season than later, and it will be probably found best to restrict

their use to the earlier period. They should never be tasted raw.

Remove half or more of the midrib of the leaf and boil for 12-15 minutes in water to which a good pinch of baking soda has been added. Drain off soda water, wash with boiling water, and then boil in water, seasoned with last, for 20-30 minutes or until tender. Other seasoning may be added as desired.

The above treatment destroys acridity, but boiling in soda water has been found unnecessary when greens are cooked with fat meat.

When uncooked dasheens are being scraped or pounded, they should be handled in water to which a teaspoonful of salsoda to the quart has been added in order to prevent irritation of the hand.

Good cooking quality in yautias and gabis means the capacity of boiling well; that is of bursting the skins in a dry and mealy condition when properly boiled, of being white in color or of such shade as the variety allows and free from any discolorations, and of having good smell and flavor. Gabis and yautias of poor flavor or that are watery or soggy or waxy in texture are all regarded as bad in quality. It is obvious that chemical analysis can give no help in the determination of flavor and color, and that observations on these properties must be made with the eye and the palate, with such liability to error as must exist under such conditions. But as quality in gabi and yautia is also largely dependent upon the dryness of the tuber, analysis can throw a very useful light on the question by determining the relative amounts of water and solids present. Determination of the percent of starch in the different varieties is also important. According to results and observations, the dry mealy conditions of tubers, which is of course esteemed, is largely dependent on the amount of starch contained in them. A high percent of nitrogenous matter may be found in soggy or watery aroids of inferior quality. Therefore, good quality in the aroids is in great measure dependent on the presence of a high percentage of starch.

Since the texture and appearance when cooked are among the final tests of quality, the physical characteristics which might be considered as factors regulating these have also been studied, and the raw tubers examined both internally and externally. The appearance of the skin of tubers may also indicate the degree of maturity or development which promises good quality.

In cooking, mealiness is the most important thing to consider in estimating quality. In all cases, mealiness follows upon the presence of sufficient starch in the cell to rupture its walls when boiled in water. The starch grain of gabi or yautia expands when boiled in water, and if the cells are sufficiently full of these bodies, boiling will cause the cellular structure to be broken down, and so result in mealiness. When the required amount of starch is not present in the cell, its walls are not broken down in cooking, therefore, the tuber retains its form or is watery. Analysis of tubers shows that immature tubers are richer in protein and poorer in starch than normally developed and ripened tubers.

The cooking and dietetic quality of the tubers of the aroids is not dependent upon chemical composition so much as upon the anatomical characteristics of the tubers and the arrangement and distribution of starch and water areas in its substance. The structural characteristics of the tubers are influenced by the conditions of the soil and by climatic conditions. It seems probable that the mealiness of a tuber when boiled, and to greater extent the flavor, are influenced by the daily range of temperature during the growing period, the degree of ripeness of the tuber when the plant matures, and the physical condition and type of soil. It is also probable that the use of different

fertilizers will influence the cooking quality of the tuber.

Climate, as affecting the distribution of seasonal rainfall and air temperature plays an important part in modifying the value of a soil for raising a good quality of tubers; so that, although a soil of good physical composition produces the best quality of tubers in a moist climate, a heavy soil may do better in a warm dry climate.

Chemical Composition

The gabi and yautia are modified stems, shortened and thickened as a reserve for materials to be used for the growth of the plant. The skin is of brownish grey corky material, rough and hairy in most varieties of gabi and in a few yautias.

The varieties of gabi and yautia under cultivation have different habits, appearance and quality; it is to be expected that the proportions of carbohydrates, protein, mineral matters and water which the plant contains should vary with the individual, with the variety, and with the character of the soil, climate and other conditions under which it grows. Furthermore, since the requirements of the gabi or yautia plant vary at different stages of growth, it will provide for them by drawing upon material stored in the tubers. Consequently, the tubers of different plants of the same variety and even individual tubers of the same plant vary in composition.

The corky material or skin of the tuber makes up the refuse of which the *per cent* depends upon the individual tuber and the variety. The skin is the only refuse or inedible portion of the tuber, but there is also part of the flesh that goes with the skin, because in practice a considerable part of the cortical layer goes with it in peeling. From tubers having irregular surfaces, and from tubers that are shrunken due to drying or storage, a greater portion of the flesh is so lost than is the case when the tubers are regular in form, smooth, and in fresh condition.

TABLE I

COMPOSITION OF TROPICAL ROOT CROPS

Kinds of food	*Water*	*Protein*	*Fat*	CARBOHYDRATES *Starch Sugars*	CARBOHYDRATES *Crude Fiber*	*Ash*
Yautias	70.0	2.2	0.2	26.1	0.6	0.9
Gabis or Taros	70.9	1.8	0.2	23.2	0.8	1.2
Irish potatoes	78.3	2.2	0.1	18.0	0.4	1.0
Sweet potatoes	69.0	1.8	0.7	26.1	1.3	1.1
Yams	72.9	1.8	0.2	23.3	0.6	0.9
Cassava	66.0	1.1	0.2	30.2	1.8	0.7

1. Potatoes and other Root Crops. United States Department of Agriculture, Farmers Bul. (1910), *295*, 30; Promising Root Crops for the South, United States Department of Agriculture, Bur. Plant Ind. Bul. 164, (1910) 14.

The analyses of Table I show that gabis and yautias do not differ very greatly in composition from the other tropical root crops. Carbohydrates constitute the chief material in each case and the principal carbohydrate present is starch.

Table II gives the composition of tubers of some of the varieties of yautias, gabis, and dasheens grown and analyzed by the writer.

TABLE II

ANALYSES OF GABIS, DASHEENS, AND YAUTIAS

Field No.	Varieties	Water	Protein	Fat	CARBOHYDRATES Starch	Dextrin & Reducing Sugars	Soluble Starch	Crude Fiber	Ash	Undt.
444	Rolliza	69.67	0.89	0.13	20.03	0.61	0.96	0.65	1.35	5.75
495	Mindoro Dasheen	67.07	1.42	0.2	18.01	0.45	1.92	0.44	1.35	9.05
308	Los Baños Dasheen (a)	74.7	1.73	0.11	15.77	0.41	0.88	0.48	0.42	5.50
308	Los Baños Dasheen (b)	71.8	1.41	0.09	16.20	0.38	0.78	1.14	2.25	3.00
950	Malabong puti (a)	80.56	0.91	0.08	11.51	0.50	1.43	0.66	1.64	2.73
950	Malabong puti (b)	77.62	1.58	0.20	14.35	0.26	4.03	0.95	0.46	0.55
310	Rough Samar	66.1	1.00	0.35	20.38	1.41	3.50	0.76	1.17	5.53

(a) Analysis of the main tuber.
(b) Analysis of the side tuber.

Table III gives analyses of *Gabis* and *Yautias* from various sources.

TABLE III

COLLECTED ANALYSES OF GABIS AND YAUTIAS

Kind of food	Water	Protein	Fat	CARBOHYDRATES Starch	Crude Fiber	Ash	Undt.
Xanthosama sagittifolium [1]	76.3	1.35	0.27	17.7	1.51	1.13	1.74
White variety of yautia [2]	70.0	1.70	0.2	.....	0.6	1.2	26.30
Yellow variety of yautia [2]	70.0	2.50	0.2	.....	0.6	0.6	26.10
Yautia [3]	73.8	3.75	0.41	18.8	1.92	1.27	.....
Gabi from Antilles [4]	74.0	2.55	0.36	16.64	1.18	1.15	3.30
Gabi from Japan [5]	83.2	1.41	0.34	13.30	0.76	1.00	.....
Gabi from Japan [5]	85.2	1.40	0.08	.....	0.63	0.99	11.70
Gabi [6]	67.2	1.90	0.20	.....	.....	1.10	29.30
Dried slices of gabi from Bismarck Archip. [7]	11.59	2.85	0.28	56.99	.....	2.33	.....

[1] Les plantes á Tubercules Alimentaires. Jumelle (1910) 275, 280.
[2] Promising Root Crops for the South, United States Department of Agriculture, Bul. 164 (1910) 14.
[3] Bul. Kolon. M. Haarlem No. 30 (1910); No. 33, Suppl. 1 (1905).
[4] Les Plantes á Tubercules Alimentaires. Jumelle (1910) 280.
[5] Digest of the Japanese Investigations on Nutrition of Man, United States Department of Agriculture, Bul. 159 (1905) 46.
[6] Hawaii Agricultural Experiment Station Annual Rpt. (1906) 76.
[7] Semler: Die tropische Agricultur, Vol. II. (1908) 812-814.

Since the previous tables give more or less complete analyses of the tubers of these aroids, the following gives only the percentages of moisture, protein, and starch in the different varieties grown by the writer. The numbers in the first column are those of the permanent cultures and serve for the future identification of the varieties. The tubers analyzed were those exhibited by the College of Agriculture at the Philippine Exposition of 1914.

TABLE IV

ANALYSES OF YAUTIAS, DASHEENS, AND GABIS

Field No.	*Variety*	*Water*	*Protein dry basis*	*Protein wet basis*	*Starch dry basis*	*Starch wet basis*
	YAUTIAS (White varieties)					
434	White tamma	62.53	2.69	1.00	40.40	15.14
444	Rolliza	58.49	4.06	1.67	67.20	27.89
309	Rolliza blanca	69.04	4.81	1.49	58.80	19.05
439	Trinidad	66.36	3.56	1.20	66.80	22.47
442	Taro Royal	71.49	4.37	1.25	21.30	6.02
438	Banana tatin	64.45	2.20	0.78	31.10	11.06
430	Malanga blanca	73.01	1.91	0.51	60.60	16.19
443	Grey Jack	67.47	4.50	1.46	35.50	11.66
436	Punyera	64.42	4.31	1.53	60.20	21.42
589	Unknown variety	74.95	3.94	0.98	61.70	15.46
587	Unknown variety (a)	76.09	7.38	1.76	56.30	13.46
587	Unknown variety (b)	66.78	7.00	2.32	24.30	8.07
588	Unknown variety (a)	64.93	4.37	1.53	62.00	21.74
	YAUTIA (Yellow variety)					
440	Prieta or Morada	49.31	4.62	2.34	66.50	33.71
	YAUTIA (Pink variety)					
441	My Lady	71.74	4.06	1.15	30.60	8.65
	COLOCASIA (gabis)					
310	Gabi Rough Samar	66:1	.....	1.00	.....	20.38
586	Wild Variety	69.28	6.56	2.01	21.60	6.63
	COLOCASIA (dasheens)					
495	Mindoro Dasheen	61.05	4.25	1.65	64.30	25.04
945	Dasheen puti	72.53	10.37	2.85	23.00	6.32
435	Colocasia dasheen	75.09	8.37	2.08	23.50	5.85
437	Colocasia dasheen	80.65	9.69	1.57	17.30	2.35
947	Dasheen lasuna	73.62	9.12	2.45	18.50	4.99
308	Dasheen Los Baños	70.88	6.25	1.82	45.90	13.37
1848	Dasheen Calamba	70.04	4.81	1.44	17.80	5.35
432	Col. Dasheen, Porto Rico No. 17	73.64	4.25	1.02	23.20	6.12
341	White Edda dasheen	71.66	7.19	2.04	28.80	7.16
433	Col. Kelly No. 6	70.68	7.00	2.05	21.60	6.33
	ALOCASIA INDICA					
121	Talban tuberculo	87.09	12.50	1.61	18.60	2.75

(a.) Main tubers.
(b.) Side tubers.

All the tubers above analyzed were about eight months old, with the exception of the Alocasia, which had been in the ground for about two years.

Tubers of the yautias were analyzed two weeks after they have been dug, and gabis and dasheens after three days.

The varying percentages of protein and of starch in the tubers of yautias gabis, and dasheens may be principally due to differences in the maturity of the tubers analyzed, but probably also to the varietal characteristics of the plants. Many of the varieties are much improved by cultivation, and since most of them have been imported, the change of soil, climatic conditions, irrigation, methods of cultivation, and other conditions probably influence the composition and character of the plants.

A sample of dried tubers of Rolliza variety has been reported as containing 29.17 per cent starch, and 62.25 per cent water. It has been found by experiment that 20 to 25 per cent starch may be extracted from fresh tubers of this variety. The yield of starch per acre is estimated to be from 8 to 15 tons as compared with 5 to 10 tons of cassava. (1)

Native malangas or gabis contain 14.94 per cent starch, and 24.40 per cent water.

(1) Experiment Station Record, Vol. 27, page 247.

Talban tuberculo (*Alocasia indica*) contains 1.615 per cent protein, and 2.12 per cent starch.

The analyses of the writer presented in Table V indicates that potash is the most important mineral food removed from the soil by the growth of yautias and gabis.

TABLE V

ELEMENTS OF PLANT FOOD IN YAUTIAS AND GABIS

	Yautia (Xanthosoma)				*Gabi (Colocasia)*			
	H_2O	*N*	*P*	*K*	H_2O	*N*	*P*	*K*
Leaves	85.50	2.18	0.083	0.270	55.0	4.95	0.145	0.35
Petiole	9.20	0.37	0.041	0.260	84.0	0.59	0.045	0.22
Main tuber	85.00	0.46	0.053	0.230	85.0	0.87	0.057	0.12
Side tuber	89.00	0.46	0.060	0.180	....	....	.....	....
Entire plant	.....	1.01	0.051	0.210	....	1.80	0.061	0.12

The organic compounds which give the flavor to gabis and yautias vary in tubers at different stages of maturity. If they are peeled or cut and exposed to the air, the outer portion of the flesh turns brown, a change probably due to some oxidizing enzyme.

Many varieties of gabi and the root stock of dasheens and Alocasias in general contain numerous bundles of crystals of calcium oxalate. Calcium oxalate is soluble in water slightly acidified with hydrochloric or nitric acid. Hence natives in preparing the leaves and petioles as greens and tubers always add vinegar or acid vegetables or fruits, such as tamarind.

The poisonous substance found in *Alocasia macrorhiza* has been stated to be hydrocyanic acid. The writer has tested the tubers of *Alocasia indica* for this poison by distilling the ground material with dilute acid, and collecting the distillate in N/10 alkali. The silver cyanide and Prussian blue tests on the neutralized liquid gave negative results.

Culture

These aroids do best in well drained sandy loam with an abundance of organic matter. A low sandy loam that is fairly well drained, but still too wet for other field crops can be used. On these low lands it is customary to plant them in ridges. The most favorable time for planting the aroids in the Philippines is through the months of May or June, that is, before or at the beginning of the rainy season.

Experiments show that it does not pay to use small tubers or cuttings for "seed" if larger ones are available, because the yield is reduced 15 to 20 per cent. The yautias are propagated by planting the main stock (madre), by the side sprouts, and by tubers; sometimes, when there is scarcity of "seed," people use cuttings of the madre and even of tubers. In the case of gabi, side sprouts or suckers, and the main stock cut about 1 or 2 inches below the top are also used for seed. In the dasheens any part of the plant except the leaves is used as seed. Tubers weighing 3 to 4 ounces are preferable for planting.

It has been the experience of the writer that planting tubers of yautias and dasheens directly in the field is not advisable. The tubers will not set sprouts, at least for a month or two, unless enough water is given to start germination. The field in all cases becomes weedy before the tubers germinate and the weeding is expensive. It is therefore advisable to plant them first in seed beds and to tranplant when the seedlings are large enough.

For field culture the tuber or sprout is planted from 3 to 5 inches deep for gabis and dasheens, and even deeper

for yautias. The distance between plants depends upon the groups and varieties of aroids and conditions of soil and climate. They may in general be planted in hills 3 feet apart, the distance between rows being 4 feet; but for dasheens shorter distances may be used to advantage. These reasonable distances will permit a vaca or a horse to pass through with a cultivator. On very wet lands, where horse tools can not be used and where weeds are killed by allowing the water to stand at intervals, a closer planting, as practised in most parts of the tropics, is advisable. In rich soil 12,000 to 25,000 plants may be set per hektare.

In the Philippines, no systematic cultivation is practised with the native gabis. They are commonly found growing along banks of rivers, wells, and rice fields and other places where water is not beyond reach. They are sometimes planted in rows but the hills are at more or less irregular distances. The fields are then allowed to run to weeds, where weeding or hoeing is impossible. The native method is to plant the sets so closed together that it results in the production of slender plants and poor yielders. In Porto Rico and Hawaii, and in some other places in the tropics, extensive cultivation is being practised with cultivated aroids because of their high productiveness, facility of culture, and fitness to local conditions. Where modern and scientific methods are used, and proper distances are given, and abundance of fertilizers and water are applied, the production is of course greater.

Where dasheens or yautias are planted on level places where the soil is rich and porous, the yield is increased twenty per cent. by a practice commonly followed in the Philippines. When plants are making tubers (side tubers), the natives throw up earth around the plants, making mounds sometimes 2 ft. high.

Maturity is recognized when the leaves of the center plant begin to dry, leaving only 1 or 2 fresh ones.

The crop of dasheens matures in about 5 to 8 months depending upon the variety, but tubers may be used for home consumption in 5 or 6 months or less, from planting. The gabis and yautias may be harvested in from 8 to 12 months; Alocasias and Cyrtospermums require more time, at least 1½ to 2 years.

Like potatoes and cassava which give heavy yields, yautias, dasheens and gabis require a well manured soil, or a naturally rich one. Experiments made at the Porto Rico Experiment Station indicate that ordinary, well rotted manure is better suited than commercial fertilizers for use on growing yautias or dasheens.[1] Stable manure applied at the rate of 30 tons per acre gave edible tubers of yautias at the rate of 16 tons per acre, as compared with 8 tons on one of the check plots. The highest yield per plant (3.22 pounds) was obtained from a plot receiving stable manure, and the lowest yield per plant, 1.6 pounds, from the check plot. A second crop of tubers was obtained from the small plants left standing after the first ripe roots had been removed. Well rotted coffee pulp on ordinary soil gave a yield of 12.4 tons per acre. Unfavorable results were obtained with chemical nitrates and phosphates. Potash seems to be the most important food.[1]

Where there is a deficiency of potash in the soil, and especially where stable manure is not available, a fertilizer

[1] E. S. R. Vol. 17, p. 351 (1905-6).
P. R. E. Sta. (1904 Annual Report), Barrett.
U. S. D. A. Bull. 164. Promising Root Crops for the South, p. 12. (1910).

rich in potash should be used. Experiments conducted in Japan[1] on the effectiveness of kainit, potash and wood ashes, showed that kainit and forty per cent. potash salt were about equally effective, and considerably more so than wood ashes. The fertilizers should be applied within a week after planting and a second application may be desirable in midsummer.

Harvesting is more costly than for sweet potato, because hand labor is mostly employed in separating, cleaning and sorting the tubers. Harvesting is done by hand pulling, aided by a mattock. A 10-inch plow has proved efficient for turning the plants over when the area grown is large enough to justify its use. Where they are to be used for home consumption, mature tubers may be dug and removed from the main plant by means of the finger or of a knife, and the plant allowed to continue growing from one and one-half to two years. This method is called "castration."[2] Reports state that by this method it is possible to harvest as much as 81 tons per hektare in that time. This method can only be practised on dasheens and yautias and not on gabis for the latter do not produce any side tubers. It is of the utmost importance that harvesting should be done during the dry season; for the tubers must be dried before being stored so as to prevent rotting.

Where soil and climatic conditions are favorable a hill of yautias may yield as much as 6 pounds of tubers, and the average of common varieties in ordinary soil may be two to four pounds per hill. The yield of gabi may be nearly the same as that of yautia. The yield of dasheens under favorable conditions may be from four to ten tons or more of tubers per hektare. Experiments conducted by the Florida Experiment Station showed that in different soils and different seasons they were able to obtain yields of from 378 to 1215 bushels per hektare.[3] Poor results were obtained, even in good soils, when two successive crops of the aroids were grown in the same ground. The yield for Alocasia is from 25 to 30 tons per hektare, which seems to be less than that of yautias.

The growing of a yautia or dasheen crop is perhaps just as expensive as that of a potato crop. The season of the dasheen and yautia, especially the latter, is longer than that of the potato.

The following table gives the production of the different varieties of yautia grown on native unfertilized lands but with frequent cultivation. The plants were harvested at the age of eight months and a half.

1 College of Agriculture, Imp. Univ. Tokyo, (1906) No. 1, p. 73-4.

2 The Yautias of Porto Rico P. R. E. Sta. Bul. 6 p. 21 (1905). Promising Root Crops for the South, U. S. D. A. Bul. 164 p. 12-13 (1910).

3) U. S. D. A. Cir. 127 (1913), p. 30.

Field No.	*Variety names.*	*Yield per hill in Kg.*		*Yield per acre in lb.*		*Yield per ha. in Kg.*	
		Madres.	*Tubers.*	*Madres.*	*Tubers.*	*Madres.*	*Tubers.*
	(Xanthosoma sagittifolium).						
444	Rolliza	....	1.1	....	11756	....	13310
309	Rolliza blanca	1.05	2.62	11180	28531	12705	317025
430	Malanga	.92	.71	9018	7731	11142	8591
436	Punyera	.15	.40	1633	4259	1815	4840
442	Taro Royal	.55	.94	5856	10009	5655	11373
584	Unknown variety	.46	1.0	4886	10648	5566	12100
587	" "	.80	1.2	8518	12777	8780	14520
588	" "	.37	.75	41597	7986	4727	9075
1678	" "	.38	.86	4046	9159	4598	10406
1720	" "	....	1.20	..	12777	....	14520
589	" "	.53	1.30	4543	14842	6412.5	16030
439	Trinidad yellow	....	1.00	..	10648	....	12100
443	Grey Jack	.44	1.50	4685	15972	5324	18150
434	White Tamma	1.3	4.0	14842	4261	16030	48400
1721	Unknown variety	4.0	....	42612	..	48400	....
1521	San Fernando Po	....	1.0	....	10648	....	12100
441	My Lady	..	.9	....	9583	....	10790
	(Xanthosoma violaceum).						
440	Prieta or Morada	.58	.55	6175	5856	7018	6655

The following table gives the production of the different varieties of dasheen grown on ordinary unfertilized lands but with frequent cultivation and irrigation. The plants were harvested at the age of seven months.

Field No.	*Variety names.*	*Yield per hill. in Kilos. (Tubers.)*	*Yield per acre in pounds. (Tubers.)*	*Yield per ha. in Kilos. (Tubers.)*
433	Dasheen Kelly No. 16	1.55	16504	18755
1637	Dasheen U. S. D. A.	.77	8199	9317
437	Unknown variety	.78	8305	9438
947	Dasheen Lasuna	1.11	11819	13431
432	Dasheen No. 17	.67	7134	8207
435	Dasheen Putí	.92	9774	11107
1845	Unknown Variety	.90	9583	10890
1847	Unknown Variety	.60	6288	7260
431	Dasheen White Edda	1.15	12245	13915
495	Dasheen Mindoro	1.8	19166	21880
1717	Dasheen Chinese Var	1.16	12131	13786
1718	Dasheen Chinese Var	1.61	17143	19481
1719	Dasheen Chinese Var	1.60	15936	18110
951	Dasheen Sungsong	.99	10628	11978
308	Dasheen Los Baños	2.09	22254	24985
944	Dasheen Malabong Pulá	1.70	18101	20570
1641	Dasheen Sinibuyas	1.3	14942	15720
1848	Dasheen Calamba	.67	7134	8107
1844	Dasheen Morong	.95	10115	11495
1711	Dasheen Karayo	1.90	20231	22990
1050	Dasheen Pinalawan	.50	5324	6650
950	Dasheen Malabong Putí	1.66	15475	17586
585	Unknown Variety	1.0	10648	12100
1846	Unknown Variety	1.42	15120	17182
1849	Dasheen Tapal	.75	7766	8825
1852	Unknown Variety	.86	7397	8406

The following table gives the production of the different varieties of gabi grown on ordinary unfertilized lands but with frequent irrigation and cultivation. The plants were harvested at the age of seven months.

Field No.	*Variety names.*	*Yield per hill. in Kilos. (Main tuber.)*	*Yield per acre in pounds. (Main tuber.)*	*Yield per ha. in Kilos. (Main tuber.)*
310	Gabi Rough Samar	.94	10009	11324
1049	Gabi Tinamban	.39	4152	4719
1044	Gabi Hinongot	.28	2951	3388
1043	Gabi Minanban	.23	2449	2783
1584	Unknown Var. (Wild)	.40	4259	4840
1638	Gabi Sanlay	.45	4798	5445
901	Gabi Kinalikot	.27	2875	3227
1053	Gabi Binaligguat	.50	5324	6050
1640	Muros	.28	2981	3388
1056	Gabi Manalod Red	.35	3726	4235
1045	Gabi Cabató	.20	2129	2420
1051	Gabi Manalod Tinampay	.35	3726	4235
1639	Gabi Sanlay	.60	6388	7260
1054	Gabi Inidclog	.23	2449	2743
1850	Unknown Var. (Wild)	.20	2129	2420
1052	Gabi Manong	.44	4778	5440
1042	Gabi Manlaban	.40	4259	4640
1047	Gabi Hinagnayon	.60	6388	7260
102	Gabi Smooth Black	.64	....	....
1055	Gabi Siniñora	.60	6388	7260
1046	Gabi Calapan	.30	3194	3630

Grading

The grading of tubers of the aroids is of great importance, if markets are to be built up. The first grade should contain only perfect tubers having uniformity of size and shape. The weight of the tubers may be from 4 to 5 ounces in the case of dasheens and 6 to 8 ounces in the case of the yautias, etc. A mechanical means of grading can be devised so that it will reduce the cost of hand labor. A simple scheme[1] is to make a wooden frame, 18 to 24 inches wide and 6 inches high, with a botton of parallel slats or wooden rods set at a convenient distance apart. To separate out tubers too small for market, the distance between rods should be one and three fourths inches. A frame of the size described will be handled very easily by a man. If the quantity of tubers is large, it becomes necessary to have a stationary grader of larger dimensions. It should be placed on an incline, so that the tubers will roll off at the lower end. If more than 2 grades are required an additional set of rods or bars at either greater or less distances apart can be placed a few inches above or below, as may be convenient. In the use of a grading apparatus and in handling such tubers, it is of the utmost importance that care be taken not to bruise them.

Diseases

On account of the crystals of calcium oxalate, the plants are protected somewhat from ,the attacks of larger animals.

During the present season most of the aroids under cultivation were more or less defoliated. The destruction was due to the green larva of a moth, *Chaerocampa celerio* L., of the family *Sphingidae*. This moth was described by Cevallos in the Philippine Agriculturist and Forester Vol. I (1911), No. 2, p. 34. The pest can be over come by the application of arsenical compounds."

There is still another larva which does nearly the same damage to gabis as the one just described. It belongs to the family *Noctuidae*. The larva when adult is about 3 centimeters long and 0.4 centimeters wide. The color is grayish black. The head is black and 4 yellow lines run along the body from the head to the end of the body. The pupa is colored dark brown, and measures about 5 millimeters in length and 2 millimeters in diameter. The moth is grayish in color and small.

The insects are most destructive to Colocasias, but somewhat so to Xanthosoma. In the case of Colocasia, black aphides are found all over the leaves, more especially along the petioles. The destructive effect is very small.

Still another insect attacks the leaves of Alocasia and the appearance is recognized by the round holes found on the leaves. This beetle is a brilliant green and belongs to the family *Chrysomelidae*. It measures one centimeter in diameter and 2 centimeters in length. The head, antennae, and lower part of the body are colored bright yellow, with brilliant green on the wings.

There are two or three forms of decay in the tuber which are due to fungi and bacteria. The decay affects the tubers which have been left in the soil for a long time, or are slightly infected with germs at the time of harvesting.

[1] U. S. D. A. Cir. 127, p. 25 to 34 (1913).